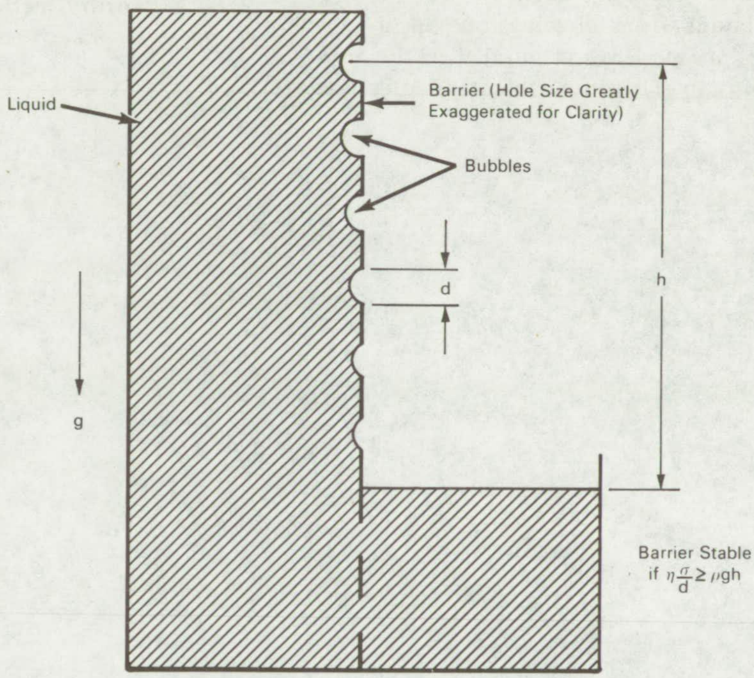
NASA TECH BRIEF

A Method for Using Surface Tension to Determine the Size of Holes in Hardware



The Functioning of Bubble Pressure in Propellant Retention

One method which is presently used to measure hole diameter is the use of precision air gauges. This Tech Brief describes a simpler and more inexpensive process for accomplishing these measurements. The concept can be used to check the size of small holes in injectors, flow control orifices, filters, and similar hardware.

The surface tension of a liquid causes it to act as a membrane when pressure is applied. The amount of pressure a membrane can support without breaking is called the bubble pressure, which is a function of the hole diameter and surface tension. It has been determined that for a hole of 0.01 inch diameter the bubble pressure is 4.6 inches of water, and for a hole of 0.001 inch diameter, 46 inches of water. This technique can be used for holes in the range between 0.010 and 0.001 diameter.

In general, capillary barriers derive their effectivity from the phenomenon of bubble pressure. That is, a pressure differential is required to force a bubble

(continued overleaf)

through a hole in a plate wetted by a liquid. Classically, for any curved liquid-gas interface, this pressure difference is given by the capillarity equation

$$\Delta P_B = \partial (1/R_1 + 1/R_2)$$

where σ is the liquid surface tension and R1 and R2 are the local principle radii of curvature. For a perfectly wetted plate where the hole geometry is regular, the maximum pressure differential (which occurs for a hemispherically shaped bubble) may be expressed as

$$\Delta P_B = \eta \, \sigma/d$$

where d is the hole diameter and η has a value of 4.

The figure shows the way in which the bubble pressure principle functions in capillary-barrier propellant retention and feedout devices. Bubble pressure prevents liquid from flowing out of a compartment despite an acceleration parallel to the barrier. Liquid remains in the compartment as long as the bubble pressure exceeds the hydrostatic pressure, ∂ gh. When the hydrostatic pressure is greater, gas bubbles enter at the "top" permitting liquid to leave the compartment.

Notes:

1. This concept may be of interest to manufacturers of injectors, flow control orifices, filters, and similar hardware.
2. This development is in conceptual stage only, and as of date of publication of this Tech Brief, neither a model nor prototype has been constructed.
3. This Tech Brief is complete in itself. No additional information is available.

Patent status:

No patent action is contemplated by NASA.

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